

WHAT DOES SINGLE PAIR ETHERNET BRING TO THE IIOT?

By Philip Ling | January 19, 2022

The IEEE standard for single pair Ethernet (SPE) was born in the automotive sector to reduce the weight of cables in a vehicle. It is now becoming hugely popular in the industrial sector, where cable weight is far from the most important feature.

According to George Zimmerman, chair of the Ethernet task force, describing single pair Ethernet isn't difficult. Explaining why it is important is a little more complex. The name really says it all: SPE is Ethernet over a single pair of twisted conductors. All other Ethernet connections have multiple pairs of conductors and the reason for that is largely legacy. Running Ethernet over a single pair isn't technically new, but using cables with just one pair is new, and it is significant for many reasons.

It really comes down to sending and receiving simultaneously. In the very early days, it was difficult to do that over a single pair, so Ethernet used two pairs, one to transmit and one to receive. Very high-speed Ethernet still makes use of those multiple pairs to split the bandwidth between them, not to transmit/receive separately.

Echo cancellation was the signal processing breakthrough that enabled simultaneous transmit/receive over the same conductors. Moore's Law enabled echo cancellation to be integrated in a smaller area using lower power, and that really makes it viable. It isn't that the task has become more complicated, it is just that we can now fit the processing power needed to do it into a smaller area.

In fact, according to Zimmerman, echo cancellation is probably simpler now than in those early days. That is because the conductors, connectors and other electromechanical elements are of higher quality. The signal-to-noise ratio has improved. That makes the task of echo cancellation a little simpler, but that is perhaps supplementary to the real task.

The point is that SPE isn't significant because it is enabled by a new technology breakthrough; it is significant because it breaks the mold. It means networks can no longer assume there will be multiple pairs available. In the industrial domain, it is significant because OEMs already prefer single pair connections. Often, they will be running other, sometimes proprietary protocols. Now, they can run Ethernet over those same connections, and that really is a game changer.

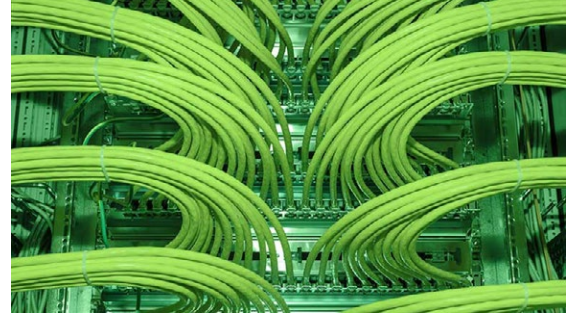
Time sensitive networking

Ethernet also is used for industrial control factors in time sensitive networking (TSN). George Zimmerman is also chair of an effort looking at the toolset for TSN that is part of IEEE 802.3. This includes the new 10BASE-T1 PHYs for TSN and looks at the future for long-reach, point-to-point single pair Ethernet. The driver here is the Industrial IoT (IIoT), closely tied in with time sensitivity. This is specifically relevant when looking at aspects such as latency in servo motor control.

While TSN is also important in automotive applications, the weight savings made by moving to SPE in the industrial world isn't the biggest draw. In fact, in a vehicle, the length of the SPE cable – or reach – is relatively short, around 15 meters using a thin gauge wire. In an Operational Technology (OT) application, the reach could be a kilometer and the gauge much thicker – as much as a millimeter in cross section. This cross section is not that different from a multiple pair cable using a smaller gauge.

The practical gains come from only having to connect two pairs, rather than multiple pairs. This makes installation and maintenance simpler. The performance gains come from being able to run anything that is designed for Ethernet over that single pair. This could remove the need for industrial gateways designed to take other protocols and convert them into a frame that can be sent over Ethernet for the backhaul. It simplifies the entire network by removing the complexity of handling multiple protocols.

For OEMs, this means they can standardize on a technology that is familiar to many more engineers: Ethernet. By reducing the complexity of the underlying transport layer, those engineers can focus on the aspects that differentiate and add value, such as implementing TSN.



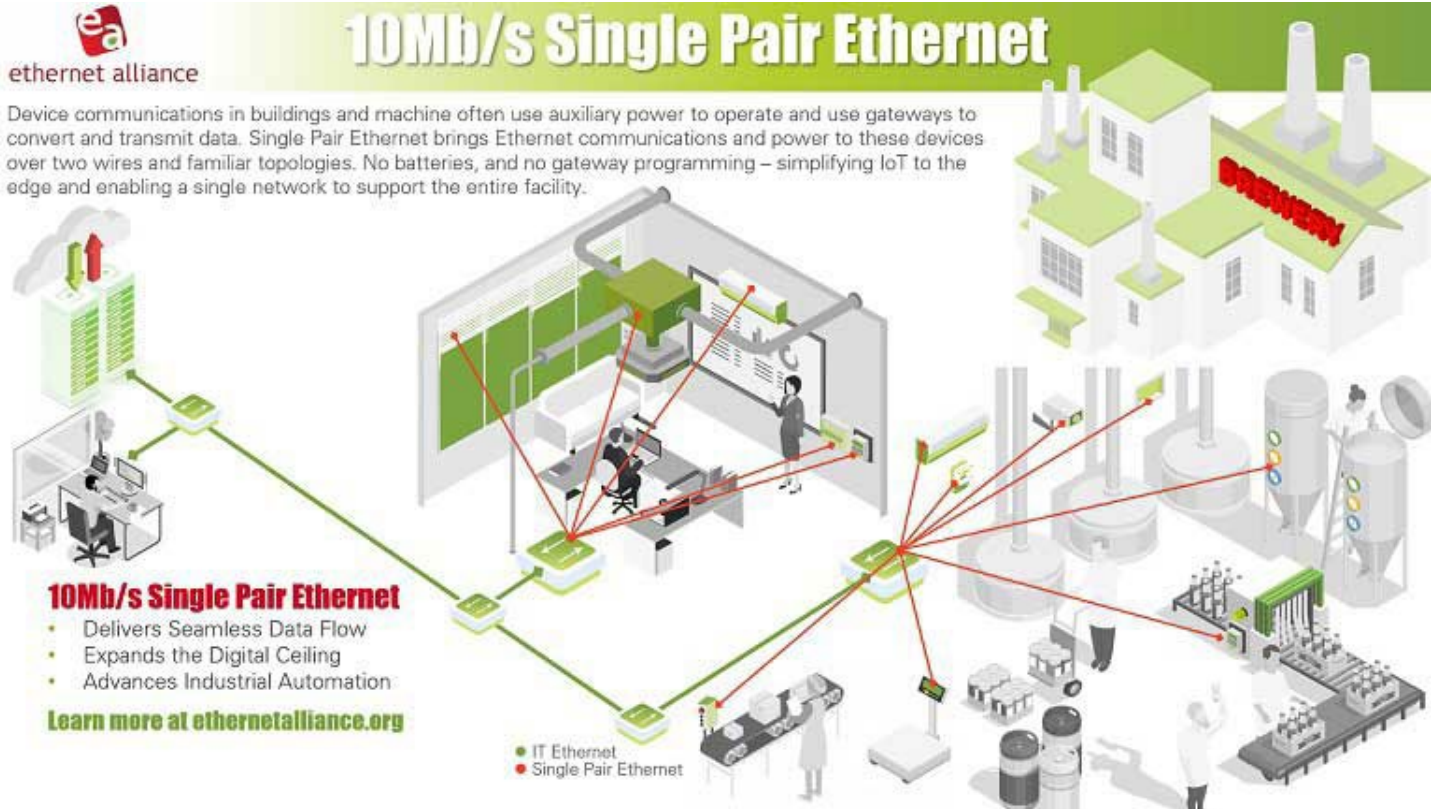
Is single pair Ethernet set to become the dominant wired connection in the Industrial IoT?



George Zimmerman

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The Ethernet Alliance developed single pair Ethernet to simplify the IIoT. Its popularity in the Industrial IIoT is growing rapidly (Source: The Ethernet Alliance)

Networking in the IIoT

Another important element driving the adoption of SPE is its ability to support shared access through multidrop technology. This is a departure from traditional point-to-point connections and, as Zimmerman pointed out, something Ethernet was originally intended to support. It does this through a technology called carrier sense multiple access with collision detect (CSMA/CD).

"10 Mbit single pair Ethernet has a version we call multidrop, which is a return to shared media connectivity," Zimmerman said. The technology was developed to replace controller area networks in vehicles. It is now being used in the industrial world as a backplane technology to connect equipment.

It simplifies the implementation of networking in an OT environment, making it both easier and cheaper thanks to the large ecosystem that already exists for Ethernet.

Power over SPE

Another important development involves delivering power with data over the same conductors. The IEEE 802.3cg specification supports 10 Mb/s for OT, while single pair power over Ethernet (SPoE) provides between 1.23W and 52W over distances of up to 1km.

"Power over wired Ethernet is hugely important. That's not just SPoE, or single pair power over Ethernet, but also PoDL or power over data lines. It's an enabler," Zimmerman said.

With so much focus on low-power applications and the use of battery or even alternative renewable sources of energy, adding power to data is really what will keep wired connectivity in the engineer's toolbox. Zimmerman, who is an independent consultant on high-performance communications

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technology and solutions, specializing in wireline communications, added: "In the past five to 10 years, around 40% of my work has been on power technologies and power over Ethernet."

In this respect, the standard offers a lot of flexibility to ensure enough power can be delivered over the single pair. "The standard specifies the maximum loop resistance," Zimmerman said. This means the wire gauge can be selected to overcome any voltage drops incurred because of resistance, in relation to the power being delivered. "The improvement we're seeing in energy efficiency for end devices is driving an explosion in the number of things you can power over these network wires, all at the same time."

Zimmerman went on to explain that we are unlikely to see single pair and multipair Ethernet in the same transceiver, at least for a while. "They are designed to be two parallel ecosystems." It is unlikely that the user would want to move between them from a physical point of view too often, but you will be able to transfer data over everything, because it's all Ethernet.

End-users are unlikely to replace multipair Ethernet cabling with single pair without good reason. But the Industrial IoT is still developing, making SPE a strong contender for the position of dominant wired standard going forward.

Zimmerman explained one of the reasons for this. In the OT world, there are already networks using slower protocols to carry Ethernet data, but they are not really Ethernet networks. They often have specific requirements, such as safety in process control environments. SPE can meet these requirements. "We did a lot of work designing 10BASE T1L so that it would be compatible with the voltage levels required for intrinsic safety in process control environments," Zimmerman said.

While SPE is not likely to displace any existing technologies without good reason, it will be the only technology suitable for some emerging applications, particularly in the IIoT. That, alone, will guarantee its success.